Acta Agrophysica, 2006, 7(2), 447-452

TRANSFORMATION OF NITROGEN COMPOUNDS IN THE MUCKOUS SOILS OF A FOREST ISLAND*

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A b s t r a c t. The investigations were carried out in 2001. The direction of the transformation of nitrogen compounds in soils under a forest island as a biogeochemical barrier located on muckous soils was presented. It was confirmed that increase of yearly mean concentrations of nitrates, ammonium, total nitrogen, total amount of bound amino acids in humic acids (HA), urease activity, dissolved organic carbon were similar to the flow of ground water under the forest island. Increase in urease activity is connected with the changes of mineral and organic forms of nitrogen.

K e y w o r d s: nitrogen compounds, muckous soils, urease activity, dissolved organic carbon, forest island

INTRODUCTION

Forest islands as biogeochemical barriers are a very important element of the landscape structure. In agricultural watersheds large amounts of migrating nutrients are leached out from cultivated soils. Forest islands have been shown to help in collecting water-borne movement of various chemical compounds from cultivated fields into the collecting eater basin [2,8].

The nitrogen cycle in soil is an integral part of the overall cycle of nitrogen in nature. From 90 to 95% of the nitrogen in the surface layer of most soils occurs in organic compounds, mainly in humic and fulvic acids. Humic acids (HA)

* The paper was presented and published in the frame of activity of the Centre of Excellence AGROPHYSICS – Contract No.: QLAM-2001-00428 sponsored by EU within the 5FP.

represent from 40 to 60% of humus. From 20 to 40% of nitrogen contained in HA is nitrogen appearing in the form of amino acids and proteins which create complexes with biologically active substances in soil [10,11].

Urease plays an important part in the transformation of nitrogen in soil. This enzyme catalysis the hydrolysis of urea with release of ammonium which can be adsorbed by soil particles and in this way it is easily accessible to plants [7].

The goal of this study was to investigate the direction of the transformation of nitrogen compounds in soils under forest island as a biogeochemical barrier located on muckous soils.

MATERIALS AND METHODS

The investigations were carried out in 2001 year in the Agroecological Landscape Park in Turew (40 km south-west from Poznań in western Polish Lowland, 16°45′ E and 52°01′ N). The subject of the study was a palace park that can be considered as a forest island. Soil samples were taken from two sites designated as site 1 and site 2. The distance between sampling points 1 and 2 was 11 m. The altitude of sampling points 1 and 2 was 78 m. Depth of the ground water ranged from 1.5 to 1.8 m below the surface. Times of sampling were from March to November in 2001, and the samples were taken from the depth of 0-20 cm after removing leaf litter. Samples were air-dried and crushed to pass a 1-mm-mesh sieve. Further procedure of the investigations followed the term „the direction of the flow of ground water" which indicated conventionally changes of concentration of nitrogen compounds along the direction of ground water flow. According to PTG (Polish Society of Soil Science), the soils were classified as division – hydrogenic soils, order – post-bog soils, type – mucky, subtype –muckous (Tab. 1).

Table 1. Mechanical composition of soils at sampling sites 1, 2 (according to PTG)

Sampling sites	Percentage of mechanical fraction (diameters in mm)						Mechanical groups
	2-0.1	0.1-0.005	0.005-0.02	0.02-0.005	0.005-0.002	< 0.002	
1	61	11	8	3	5	12	heavy loamy sand
2	60	9	10	3	5	13	light loam

The contents of organic and dissolved organic carbon were determined using a TOC-5050A analyser (Shimadzu, Japan). Total nitrogen in soils was estimated by the Kjeldahl method, ammonium and nitrate ions by the distillation method (1 N HCl) [6], and urease activity by the Hoffman and Teicher technique.

Humic acids were extracted from soils with 0.1 M $Na_4P_2O_7$ 10 H_2O at pH 7.00 ± 0.01 under nitrogen atmosphere. Bound amino acids in HA were identified and quantified using an automatic amino acids analyser: T339 Microtechna-Prague [15].

RESULTS AND DISCUSSION

Soil organic matter forms the largest pool of nitrogen in forest ecosystems. The total amount of organic nitrogen in soils varies greatly and is influenced by those factors that affect the organic matter content of the soil, namely, the soil-forming factors of climate, topography, vegetation, parent material, and age [12].

In analysed soil samples, regardless of the sampling period, an increase of the total nitrogen content was observed in the direction of the flow of ground water from point 1 to point 2 (Tab. 2).

Table 2. pH (in H_2O), N-total (mg kg^{-1} d.m. of soil), N-NH_4, N-NO_3 (mg kg^{-1} d.m. of soil), urease activity (μmol urea hydrolysed h^{-1} g^{-1} d.m. of soil), dissolved organic carbon (g kg^{-1}), humus (g kg^{-1} d.m. of soil), C/N at sampling sites 1, 2 in 2001

Sampling sites	Dates of sampling									
	19.III	6.IV	7.V	5.VI	2.VII	7.VIII	11.IX	9.X	6.XI	$\bar{x} \pm \Delta X$
pH										
1	6.9	7.1	7.0	6.9	7.1	7.2	7.1	7.1	7.0	6.9-7.2
2	6.9	7.2	7.0	7.0	7.2	7.3	7.2	7.2	7.1	6.9-7.3
N-total										
1	1680	1666	1652	2408	2632	2016	1930	2604	3136	2191.6±1217.8
2	2016	2100	3444	3080	3220	2492	2660	3108	4564	2964.9±1795.6
N-NH_4										
1	14	11	7	11	23	26	33	18	26	18.8±20.1
2	18	21	24	53	42	30	20	27	22	28.6±26.9
N-NO_3										
1	14	20	17	20	23	30	36	28	32	24.4±17.1
2	17	25	33	55	46	37	30	22	28	32.6±27.6
urease activity										
1	16.9	40.2	55.2	73.9	53.9	32.3	13.0	54.3	62.0	44.6±47.5
2	29.3	45.0	57.8	93.0	59.0	38.0	19.0	66.2	75.4	53.6±53.7
dissolved organic carbon										
1	–	–	0.62	–	–	0.79	–	–	0.69	–
2	–	–	0.90	–	–	0.92	–	–	0.86	–
humus										
1	43	51	41	70	70	54	51	47	54	53.4±24.0
2	41	29	36	58	58	61	61	49	48	49.0±26.8
C/N										
1	15	17	14	17	9	16	15	10	10	13.7±7.3
2	12	8	6	11	11	14	13	9	6	10.0±6.7

$\bar{x} \pm \Delta X$ – confidence interval of average at confidence level $\alpha = 0.05$ for n-1 degree of freedom

The lowest increase was found in March and ranged from 1680 to 2016 (mg kg^{-1} d.m. of soil), and the highest in May – from 1652 to 3444 (mg kg^{-1} d.m. of soil). A similar trend was observed for yearly mean concentrations of ammonium and nitrates (Tab. 2). The increase of ammonium ions was 34% and that of nitrate ions

25%. Both inorganic forms of nitrogen are mobile that is subject to leaching and movement into water supplies [5].

It was shown that increase of the urease activity of the muckous soils ranged from 5 do 42%, similar to the flow of ground water (Tab. 2). The highest increase of the urease activity was noted in March – from 16.9 to 29.3 (μmol urea hydrolysed h^{-1} g^{-1} d.m of soil) and the lowest in May – from 55.2 to 57.8 (μmol urea hydrolysed h^{-1} g^{-1} d.m of soil). Enzymes in the soil are obviously involved in the decomposition of organic matter and many other chemical transformations. It is known that environment conditions affect microbial activities. Increase of ureolytic bacteria biomass is more favourable at neutral pH [1]. The present study showed that pH values of muckous soils were neutral (Tab. 2).

Fourteen to nineteen amino acids were identified and determined in all HA samples. Amino acids belonging to fractions of humic-protein are elements of organic soil colloids. The colloidal character of muckous soil is stronger than that of most mineral soils. A characteristic feature of organic soil colloids is the high content of various functional groups (-NH_2, =NH, -SH, -COOH), as a result of which they possess ion-exchange and complexing properties. They can transport complexes of nutrients for plants and soil organisms [9,13,14]. The aim of correctly investigating the changes in the content of bound amino acids in HA was to show their concentration in the total form. The highest content of the total amount of bound amino acids in HA reached 3.934 (g kg^{-1}d.m. HA) in June (point 2) (Tab. 3).

It was confirmed that, similar to the flow of ground water along the 11 m strip in muckous soils, there was a significant increase of the total amount of bound amino acids in HA from point 1 to 2 (except in April and October) [14]. The lowest increase was observed in August (2.636-2.788 g kg^{-1} d.m. HA) and the highest was estimated in June (2.377-3.934 g kg^{-1} d.m. HA) (Tab. 3).

Dissolved organic matter can contribute significantly to the cycling of soil nutrients. Generally, litter, root exudates and microbial degradation products are regarded as the most important dissolved organic carbon sources. Dissolved organic carbon is the most important substrate for microorganisms, likewise for ureolytic bacteria, and a major vehicle for the leaching of nitrogen from the forest floor [3,4]. In muckous soils, an increase in dissolved organic carbon content from 14 to 31% was observed in parallel to the flow of ground water (Tab. 2).

The content of humus in mineral-organic soils ranged from 29 to 70 (g kg^{-1} d.m. of soil) (Tab. 2). In muckous soils an increase of mineral and organic nitrogen content conforming to the direction of the flow of ground water from point 1 to point 2 was observed. Additionally, there was a confirmed increase of urease activity and dissolved organic carbon. This phenomenon can be due to different conditions of humification and the input of additional nitrogen compounds from decomposition of plant residues and root-exudates. Assimilation of inorganic forms of nitrogen in the microbial

biomass through the immobilization process leads to the transformation of inorganic nitrogen into organic forms with subsequent incorporation into humic substances.

Table 3. The total amount of bound amino acids in HA (g kg^{-1} d.m. HA)

Dates and points of sampling	The total amount of bound amino acids in HA
24.04.	
1	2.534
2	2.363
20.05.	
1	1.956
2	2.913
20.06.	
1	2.377
2	3.934
21.07.	
1	2.107
2	2.555
20.08.	
1	2.636
2	2.788
19.09.	
1	2.641
2	3.701
27.10.	
1	2.522
2	2.419

CONCLUSIONS

1. It was confirmed that increase of yearly mean concentrations of nitrates, ammonium, total nitrogen, total amount of bound amino acids in HA, urease activity, dissolved organic carbon were similar to the direction of the flow of ground water.

2. Increase in urease activity is connected with the transformations of mineral and organic forms of nitrogen.

REFERENCES

1. **Abrayman S.A.:** Variation of enzyme activity of soil under the influence of natural and anthropogenetic factors. Euras. Soil Sci., 25, 57-74, 1993.
2. **Burgess R.L., Sharpe D.M.:** Forest island dynamics in man-dominated landscapes. Springer-Verlag, New York, Heidelberg, Berlin, Ecol. St., 41, 267-272, 1981.
3. **Compton J.E., Boone R.D.:** Soil nitrogen transformations and the role of light fraction organic matter in forest soils. Soil Biol. Biochem., 34, 933-943, 2002.
4. **Marschner B., Bredow A.:** Temperature effects on release and ecologically relevant properties of dissolved organic carbon in sterilised and biologically active soil samples. Soil Biol. Biochem., 34, 459-466, 2002.
5. **Mazur T.:** Nitrogen in Arable Soils (in Polish). PWN Warszawa, 1991.

6. **Ostrowska A., Gawliński S., Szczubiałka Z.:** Methods of Analysis and Estimation of Soil and Plants Properties (in Polish). Instytut Ochrony Środowiska, Warszawa, 1991.
7. **Pancholy S.K., Rice E.L.:** Soil enzyme in relation to old field succession: amylase, cellulase, invertase, dehydrogenase and urease. Soil Sci. Soc. Am. Proc., 37, 47-50, 1973.
8. **Ryszkowski L., Bartoszewicz A., Kędziora A.:** Management of master fluxes by biogeochemical barriers at the agricultural landscape level. Landscape Ecol., 14, 479-492, 1999.
9. **Schnitzer M., Khan S.U.:** Soil Organic Matter. Elsevier Scientific Publishing Company, Amsterdam, 1978.
10. **Schnitzer M., Preston C.M.:** Analysis of humic acids by solution and solid-carbon-13 nuclear magnetic resonance. Soil Sci. Soc. Am. J., 50, 326-331, 1986.
11. **Senwo Z.N., Tabatabai M.A.:** Amino acid composition of soil organic matter. Biol. Fert. Soils, 26, 235-242, 1998.
12. **Stevenson F.J.:** Humus Chemistry Genesis, Composition, Reactions. A Wiley-Intercience Publication, USA, 1982.
13. **Szajdak L., Maryganova V., Meysner T., Tychinskaja L.:** Study of humic acids under new shelterbelt in agricultural landscape. XIX International Seminar RAMIS on Modern Magnetic Resonances, Poznań-Będlewo, 34, 2001.
14. **Szajdak L., Matuszewska T., Tsekhanowitch Y., Strigutsky V., Blecharczyk A.:** Humic acids from the soils under rye monoculture and crop rotation (in Polish). Zesz. Probl. Post. Nauk Roln., 452, 93-107, 1997.
15. **Szajdak L., Österberg R.:** Amino acids present in humic acids from soils under different cultivations. Environ. Int., 22(3), 331-336, 1996.

PRZEMIANY ZWIĄZKÓW AZOTU W GLEBACH MURSZASTYCH WYSPY LEŚNEJ

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S t r e s z c z e n i e. W pracy przedstawiono kierunek przemian związków azotu w glebach murszastych na przykładzie wyspy leśnej pełniącej funkcję bariery biogeochemicznej. Wykazano w badanych glebach zwiększenie średnich sezonowych zawartości jonów amonowych i azotanowych oraz azotu ogólnego i sumarycznej zawartości aminokwasów związanych w kwasach huminowych (HA) w kierunku zgodnym z przepływem wody gruntowej. To samo zjawisko zaobserwowano dla zmian aktywności ureazy i rozpuszczonego węgla organicznego.

S ł o w a k l u c z o w e: związki azotu, gleby murszaste, aktywność ureazy, rozpuszczony węgiel organiczny, wyspa leśna